Initialization

```
import pandas as pd
import numpy as np
import networkx as nx
import matplotlib.pyplot as plt
from community import community_louvain
%matplotlib inline
from scipy.spatial.distance import cosine
```

```
df = pd.read_csv ('https://raw.githubusercontent.com/thatNitinVinayak/Inventory-Management-using-IoT/main/References/Reference%20Code/
```

```
df.head()
```

	Order ID	Product	Quantity Ordered	Price Each	Order Date	Purchase Address
0	176558	USB-C Charging Cable	2	11.95	04/19/19 08:46	917 1st St, Dallas, TX 75001
1	NaN	NaN	NaN	NaN	NaN	NaN
2	176559	Bose SoundSport Headphones	1	99.99	04-07-2019 22.30	682 Chestnut St, Boston, MA 02215
3	176560	Google Phone	1	600	04-12-2019 14.38	669 Spruce St, Los Angeles, CA 90001

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

```
path = '/content/drive/My Drive/Colab Notebooks/OnlineRetail.xlsx'
dataset = pd.read_excel(path)
```

```
print('Dataset Dimensions : ', dataset.shape)
dataset.describe(include = 'all')
```

```
Dataset Dimensions :  (541909, 8)
<ipython-input-7-94a0e184a5b8>:2: FutureWarning: Treating datetime data as categorical rather than nume
  dataset.describe(include = 'all')
```

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Cou
count	541909.0	541909	540455	541909.000000	541909	541909.000000	406829.000000	54
unique	25900.0	4070	4223	NaN	23260	NaN	NaN	
top	573585.0	85123A	WHITE HANGING HEART T-LIGHT HOLDER	NaN	2011-10-31 14:41:00	NaN	NaN	U King
freq	1114.0	2313	2369	NaN	1114	NaN	NaN	49
first	NaN	NaN	NaN	NaN	2010-12-01 08:26:00	NaN	NaN	
last	NaN	NaN	NaN	NaN	2011-12-09 12:50:00	NaN	NaN	
mean	NaN	NaN	NaN	9.552250	NaN	4.611114	15287.690570	
std	NaN	NaN	NaN	218.081158	NaN	96.759853	1713.600303	
min	NaN	NaN	NaN	-80995.000000	NaN	-11062.060000	12346.000000	
25%	NaN	NaN	NaN	1.000000	NaN	1.250000	13953.000000	
50%	NaN	NaN	NaN	3.000000	NaN	2.080000	15152.000000	

```
dataset_sample = dataset.iloc[:4000]
```

Data Preprocessing

```
# Delete Rows with no Customer ID (if there is such a case)
cleaned_retail = dataset_sample.loc[pd.isnull(dataset_sample.CustomerID) == False]

# Create a Lookup Table
```

```
item_lookup = cleaned_retail[['StockCode', 'Description']].drop_duplicates()
item_lookup['StockCode'] = item_lookup.StockCode.astype(str)

# Data Cleaning to Raw Data
cleaned_retail['CustomerID'] = cleaned_retail.CustomerID.astype(int)
cleaned_retail = cleaned_retail[['StockCode', 'Quantity', 'CustomerID']]
grouped_cleaned = cleaned_retail.groupby(['CustomerID', 'StockCode']).sum().reset_index()
print()
grouped_cleaned.Quantity.loc[grouped_cleaned.Quantity == 0] = 1
grouped_purchased = grouped_cleaned.query('Quantity > 0')
```

```
<ipython-input-9-6d2fc95d9cd0>:9: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  cleaned_retail['CustomerID'] = cleaned_retail.CustomerID.astype(int)
/usr/local/lib/python3.8/dist-packages/pandas/core/indexing.py:1732: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  self._setitem_single_block(indexer, value, name)
```

```
# Count Number of Products and Number of Customers in the Reduced Dataset
products_num = len(grouped_purchased.StockCode.unique())
customers_num = len(grouped_purchased.CustomerID.unique())
print('Number of Customers in Dataset:', customers_num)
print('Number of Products in Dataset:', products_num)
```

```
Number of Customers in Dataset: 137
Number of Products in Dataset: 1131
```

Creation of Bipartite Graph

```
# Turn Raw Data to Pivot ('ratings' Matrix)
ratings = grouped_purchased.pivot(index = 'CustomerID', columns = 'StockCode', values = 'Quantity').fillna(0).astype('int')
# Binarize the Ratings Matrix (indicate only if a customer has purchased a product or not)
ratings_binary = ratings.copy()
ratings_binary[ratings_binary != 0] = 1
```

Conversion to a Weighted Product Graph

```
# Initialize Zeros Dataframe for Product Interactions
products_integer = np.zeros((products_num, products_num))

# Count how many times each Product Pair has been Purchased
print('Counting how many times each pair of products has been purchased...')
for i in range(products_num):
    for j in range(products_num):
        if i != j:
            df_ij = ratings_binary.iloc[:,[i,j]] # Create a Temporary Dataset 'df' with only i and j Products as Columns
            sum_ij = df_ij.sum(axis=1)
            pairings_ij = len(sum_ij[sum_ij == 2]) # if s1_ij == 2 it means that both Products were Purchased by the Same Customer
            products_integer[i,j] = pairings_ij
            products_integer[j,i] = pairings_ij
```

```
Counting how many times each pair of products has been purchased...
```

```
# Count how many Customers have Purchased each Item
print('Counting how many times each individual product has been purchased...')
times_purchased = products_integer.sum(axis = 1)
```

```
Counting how many times each individual product has been purchased...
```

```
print (times_purchased)
```

```
[30. 73. 27. ... 20. 63. 34.]
```

Building Product Matrix

```
# Construct Final Weighted Matrix of Item Interactions
print('Building weighted product matrix...')
```

```
products_weighted = np.zeros((products_num, products_num))
for i in range(products_num):
    for j in range(products_num):
        if (times_purchased[i] + times_purchased[j]) != 0: # Make sure you do not Divide with Zero
            products_weighted[i,j] = (products_integer[i,j])/(times_purchased[i]+times_purchased[j])
```

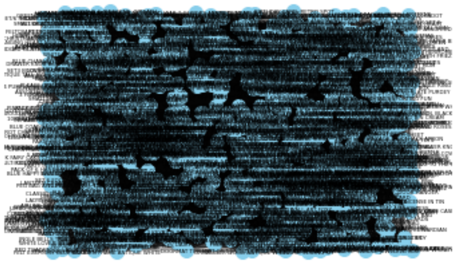
```
Building weighted product matrix...
```

Visualization of Weighted Product Matrix

```
# Get List of Item Labels (instead of Codes)
nodes_codes = np.array(ratings_binary.columns).astype('str')
item_lookup_dict = pd.Series(item_lookup.Description.values,index = item_lookup.StockCode).to_dict()
nodes_labels = [item_lookup_dict[code] for code in nodes_codes]
```

```
# Create Graph Object using the Weighted Product Matrix as Adjacency Matrix
G = nx.from_numpy_array(products_weighted)
pos = nx.random_layout(G)
labels = {}
for idx, node in enumerate(G.nodes()):
    labels[node] = nodes_labels[idx]

nx.draw_networkx_nodes(G, pos, node_color = "skyblue", node_size = 100)
nx.draw_networkx_edges(G, pos,  edge_color = 'k', width = 0.3, alpha = 0.5)
nx.draw_networkx_labels(G, pos, labels, font_size = 4)
plt.axis('off')
plt.show()
```



Exporting the Graph to Gephi

```
H = nx.relabel_nodes(G, labels) # Create a New Graph with Description Labels and Save to Gephi for better Visualizations
nx.write_gexf(H, "products.gexf")
```

Louvain Clustering

```
# Function for Setting Colors of Nodes and Edges
def get_paired_color_palette(size):
    palette = []
    for i in range(size * 2):
        palette.append(plt.cm.Paired(i))
    return palette

# Find Communities of Nodes (products)
louvain = community_louvain.best_partition(G, resolution = 1.5)
values = list(louvain.values())

communities = []

for i in set(louvain.values()):
    nodelist = [n for n in G.nodes if (louvain[n] == i)]
    communities.append(nodelist)
```

Visualize Detected Communities

```
# Make Plot using matplotlib, networkx spring_layout, set_colors using cluster_count and get_paired_color_pallette
clusters_count = len(set(louvain.values()))
plt.figure(figsize = (10, 10))
light_colors = get_paired_color_palette(clusters_count)
dark_colors = get_paired_color_palette(clusters_count)
```

```
g = nx.drawing.layout.spring_layout(G, weight = 'weight')

# Iterate through each of the Communities found by the Louvain Algorithm and Plot
for i in set(louvain.values()):
    nodelist = [n for n in G.nodes if (louvain[n] == i)]
    edgelist = [e for e in G.edges if ((louvain[e[0]] == i) or (louvain[e[1]] == i))]
    node_color = [light_colors[i] for _ in range(len(nodelist))]
    edge_color = [dark_colors[i] for _ in range(len(edgelist))]
    nx.draw_networkx_nodes(G, g, nodelist = nodelist, node_color = node_color, edgecolors = 'k', label = i)
    nx.draw_networkx_edges(G, g, edgelist = edgelist, alpha = .5, edge_color = edge_color)

# Set Title, Legend and ShowPplot
plt.title('Communities in Commodity Purchase Trend', fontdict = {'fontsize': 25})
plt.legend()
plt.axis('off')
plt.show()
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-35-63b50e2bc866> in <module>
      4 light_colors = get_paired_color_palette(clusters_count)
      5 dark_colors = get_paired_color_palette(clusters_count)
----> 6 g = nx.drawing.layout.spring_layout(G, weight = 'weight')
      7 
      8 # Iterate through each of the Communities found by the Louvain Algorithm and
Plot

                              3 frames

/usr/local/lib/python3.8/dist-packages/networkx/convert_matrix.py in
to_scipy_sparse_array(G, nodelist, dtype, weight, format)
    591             r += diag_index
    592             c += diag_index
--> 593         A = sp.sparse.coo_array((d, (r, c)), shape=(nlen, nlen),
dtype=dtype)
    594     try:
    595         return A.asformat(format)

AttributeError: module 'scipy.sparse' has no attribute 'coo_array'
```

Colab paid products - Cancel contracts here

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